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Proximate composition of housefly (*Musca domestica*) maggots cultured on different substrates as potential feed for Tilapia (*Oreochromis niloticus*)

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Abstract
The high cost of importing fish feeds into Ghana has necessitated the search for possibly cheaper substitute feed with high nutritional value. The proximate composition of housefly maggots (*Musca domestica*) cultured on animal blood and digester, poultry waste and brewer's spent (pito waste) was analyzed. There was significant ($p<0.05$) difference in the proximate composition of maggots from the different substrates. Poultry waste seems to be a promising substrate to be used in maggots' production for maggot meal. However, any of the understudied substrates have the tendency to be used for the production of maggot meal to feed fish since they all have competitive nutrient values.

Keywords: maggots, magmeal, fishmeal, animal blood and digester, poultry waste, brewer's spent

1. Introduction
Aquaculture is an industry that deals mainly with the production of fish under a controlled environment [10]. Fish production plays a very vital role in developing countries as it serves as both food and source of income for a lot of people [18]. In Africa, fish serves as one of the cheapest sources of protein for a very large number of people [12]. Demand for fish as food in Africa is on the rise as a result of it being a cheap source of protein as reported by [20].
However, the development of fish production in Africa is very slow compared to other parts of the world [14].
One of the main problems to the development of the aquaculture industry in Africa is the absence of indigenous nutritionally "high-quality" feed to feed the fishes [20]. Little attention has been given to the development of fish feed in aquaculture in Africa and other developing countries of the world [19]. Majority of fish farmers in Africa depend on foreign imported fish feed for fish production [1]. This has resulted in an increase in the total cost of fish production. This high cost of production is also a major factor that has resulted in the slow development of aquaculture in Africa [24].
The production of indigenous fish feed will go a long way to increase the rate of development of aquaculture in Africa by reducing feed cost and hence reducing the total cost of fish production [20]. This study was therefore carried out to locally produce magmeal on different substrates to feed Tilapia (*Oreochromis niloticus*).

2. Materials and Methods
2.1 Project site
Housefly maggots used for magmeal were cultured in the Spanish laboratory of the University for Development Studies (UDS), Nyankpala Campus. UDS, Nyankpala campus is located in the Tolon District of the Northern Region of Ghana on latitude 9º 25'41''N, longitude 0^{O} 58' 42'' W and at an altitude of 183 m above sea level in the Guinea Savannah Zone [30].

2.2 Substrate preparation, inoculation and harvesting
Poultry waste was mixed thoroughly and 1.0 liters of water added to moisten it. The animal digester and brewers spent (pito waste) were each also thoroughly mixed to make a good composition. Plastic containers (bioreactors) were filled with 200 g of each substrate. Two (2) ml of dawadawa (*Parkia bigglobosa*) paste was then added to each of the substrates.
The bioreactors were left in an open air for six (6) hours to allow the houseflies to inoculate their eggs on the substrates. The bioreactors were then completely covered with perforated lids and transferred to a net enclosed airy area to allow the growth of the eggs leading to maggot formation.

2.3 Maggots harvesting

The first harvesting was carried out after 24 hours using a plastic spoon. Subsequent harvesting was done at 24 hours interval.

2.4 Proximate analysis

Proximate analysis was carried out as recommended by the Association of Official Analytical Chemist [6]. The parameters determined were moisture, ash, crude protein, crude fiber, ether extract, and carbohydrates.

3. Results

3.1 Proximate composition

The average proximate composition of maggots that were cultured on the three (3) different types of substrate is shown in table 1 below.

Table 1: Average proximate composition of maggots cultured on poultry waste, animal digester, and brewers spent reported on dry matter basis

Parameter	Composition (%)
Crude Fiber	5.54
Ash	6.80
Crude Protein	56.96
Ether Extract	24.56
Moisture	1.78
Carbohydrates	4.37

The proximate composition of maggots that were cultured on the different types of substrate is shown in table 2 below. The results indicate a significant difference ($p<0.05$) in the proximate composition of maggots obtained from the different substrates.

Table 2: Proximate composition of maggots cultured on different substrates

Parameter	Animal Digester	Poultry Waste	Brewers Spent
Crude Fiber	5.83 ± 0.05^a	7.00 ± 0.05^b	3.80 ± 0.05^c
Ash	5.50 ± 0.05^a	8.50 ± 0.05^b	6.40 ± 0.05^c
Crude Protein	58.77 ± 0.08^a	59.97 ± 0.08^b	52.13 ± 0.08^c
Ether Extract	22.73 ± 0.06^a	22.27 ± 0.06^b	28.67 ± 0.06^c
Moisture	1.64 ± 0.03^a	1.76 ± 0.03^b	1.93 ± 0.03^c
Carbohydrates	5.53 ± 0.06^a	0.50 ± 0.06^b	7.07 ± 0.06^c

*Mean ± SEM values with different superscripts in the same row are significantly different ($p<0.05$)

4. Discussions

4.1 Proximate composition of maggots

Fiber is very important in fish feed as it gives it the physical bulkiness. The presence of fibre in feed improves "binding and moderates the passage of feed through the alimentary canal" [11]. Even though fiber is essential in fish feed, levels exceeding 8-12 % in feed is not advisable as it "lowers digestibility of nutrients" [15]. Maggots produced from poultry waste with a crude fiber composition of 7.00 % (table 2) will provide the most adequate fibre content to aid in tilapia growth. Average crude fiber content (5.54 %) of the maggots (table 1) was a little bit lower than the 6.30 % obtained by [8] and 7.50 % reported by [5] for maggot meal generated from a mixture of cattle blood and wheat bran.

Ash content provides a measure of the total amount of minerals within a food. Fish require the same minerals as terrestrial animals for tissue formation, osmoregulation, and other metabolic functions. Minerals are of prime importance in determining the nutritional value of feed [26]. In addition to the minerals in fish feed, dissolve minerals in the water can also be used by the fish to satisfy its mineral requirements [21]. Maggots produced from poultry waste with an ash content of 8.50 % (table 2) will be a good source of minerals compared to the rest. Ash content (6.80 %) of maggots produced from the three substrates (table 1) was below the 11 % reported by [13], 8.41 % by [33], and 9.72 to 16 % by [34] for maggots.

Protein is the major growth promoting factor in feed. The protein requirement of fish is determined by various factors such as fish size, water temperature, feeding rate, availability, quality of natural foods, and overall digestible energy content of diet [27]. Giving a fish the correct amount of protein is very important in ensuring good growth and health [22]. Protein deficiency means slower growth whereas excessive protein will put up the feeding cost. Most fish studied require a feed with 25 to 50 % crude protein. Feeds should therefore be formulated to contain the right amount of protein [35]. Maggots from all the three substrates above (table 2) will provide the required level of crude protein when used as feed for tilapia. However, maggots from poultry waste will provide a higher level of crude protein (table 2) and may serve as an excellent source of protein for tilapia compared to the rest. Maggots produced in this study contained high crude protein (56.96 %) than the 47.10 % reported by [5], 41.30 % by [34], 45.0 % by [7], 45.0 % by [16] but falls within the range (40 to 61.4 %) reported by [2].

"Neutral lipids (fats and oils), in the form of triglycerides, provide a concentrated source of energy for aquatic species". Lipids found in feed also supplies essential fatty acids that cannot be produced by the organism [31]. A diet lacking essential acids decreases the weight gain by fish fed on them. This is because the essential fatty acids required are obtained from "endogenous tissue lipids" [22]. Brewers spent may therefore be the ideal substrate to produce maggots to feed tilapia as far as crude fat composition is concerned judging by the level of ether extract (table 2) of these maggots compared to the rest. The ether extract content obtained (24.56 %) is in close agreement with the 25.3 % reported by [5] for crude fat but higher than the 8.5 % reported by [34] and the 15.63 % reported by [3].

Carbohydrates in fish diets serve as a source of energy. Apart from the supply of energy, soluble carbohydrates in fish feed also gives "pellets integrity and stability and make them less dense" [22]. Maggots cultured on the brewers spent may therefore supply adequate energy to tilapia fed on it compared to the rest. This is due to the high level of carbohydrates (table 2) in these maggots.

Compared to low moisture, high moisture fish feed becomes moldy easily. It is vulnerable to bacteria and parasites and hence must be stored well. [9] concluded in their studies that, storage of maggot meal can result in deterioration by fungi and bacteria if the moisture content is too high. They suggested drying to 4-5 % moisture to reduce bacteria activity. The average moisture content (1.78 %) as reported on dry matter basis of maggots cultured on the three substrates (table 1) can therefore be said to be very good in terms of storage.

4.2 Comparison of proximate composition of maggots produced with reported values of other meals for feeding fish.

High-quality fishmeal normally contains between 60 % and 72 % crude protein by weight [28]. [29] also reported that the crude protein content can vary from 57 to 77 %, depending on the species of fish used. Maggot meal from this study had lower crude protein content of 56.96 % (table 1) than the ones reported by [28] but within the range reported by [29] for fishmeal above. Ash content of magmeal (6.80 %) was lower than the 7.3 % reported by [32] for fishmeal. Crude fiber composition (5.54 %), percentage ether extract (24.56 %) and carbohydrate content (4.37 %) of maggots from the three substrates (table 1) were found to be higher than the reported values of 1.2 %, 8.0 %, and 3.2 % [32] respectively for fishmeal. Moisture content (1.78 %) from this study was however lower than the 8.9 % reported by [32].

Other meals that have also been reported as fish fed include earthworm, termite, garden snail, and tadpole meals. Earthworm meal has been reported to contain 63 % crude protein, 5.9 % crude fat, 1.9 % crude fiber, 8.9 % ash, 11.8 % NFE, and 8.6 % moisture. Garden snail meal has also been reported to contain 66.8 % crude protein, 7.9 % crude fat, 4.1 % crude fiber, 6.5 % ash, 5.8 % NFE, 9.0 % moisture. Termite meal also has been reported to have a proximate composition of 46.3 % crude protein, 30.1 % crude fat, 7.3 % crude fiber, 3.6 % ash, 19.0 % NFE, and 3.7 % moisture. Moreover, skinned tadpole meal has been reported to be made up of crude protein of 47.8 %, crude fat of 11.6 %, crude fiber of 3.0 %, 27.7 % of ash, 3.4 %, and NFE, 6.5 % moisture [32]. On the average, crude protein of maggots (56.96 %) obtained from this study is lower than that of earthworm meal (63.0 %) and garden snail meal (66.8 %) but higher than termite meal (46.3 %) and skinned tadpole meal (47.8 %). Crude fat of magmeal from this study (24.56 %) is higher than earthworm meal (5.9 %), garden snail meal (7.9 %), skinned tadpole meal (11.6 %) but lower compared to that of termite meal (30.1 %). The crude fiber content (5.54 %) shows a better competition among earthworm meal (1.9 %), garden snail meal (4.1 %), skinned tadpole meal (3.0 %) but was lower than 7.3 % of termite meal. The ash content (6.8 %) also showed considerable competition among the other meals stated above. The carbohydrate (4.37 %) composition was however lower than the reported values above but the moisture (1.78 %) content was lower than all other meals reported above.

The proximate composition of maggots cultured on the three different substrates in this study, is a reflection of the nutritive quality and acceptance of this biomaterial. This also corroborates previous observation that maggot meal, like other animal protein sources has been accepted and utilized by fish [4, 23]. [25] reported that maggots are easily digested by fish and this has been attributed to its relatively high crude fiber content, which according to [17] plays a significant role in feed digestion. It has also been reported that the biological value of maggot meal is equal to that of fish meal [2]. This fact is strengthened by the results obtained in the present study. Utilization of maggot meal will thus pave way for cheaper and nutritionally rich aquaculture feeds.

5. Conclusion

The study has shown that, house fly maggot is a nutritionally viable alternative feed to other sources of feed in aquaculture. Nutritionally, poultry waste is a promising substrate for the culturing of housefly maggots. However, any of the understudied substrates have the tendency to be used for the production of maggot meal to feed fish since they all have competitive nutrient values.

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